

# **Meteorological Modeling Analyses of Data Captured During the CRPAQS Field Program**

**Prepared by:  
Neil Wheeler, Ken Craig, and Steve Reid  
Sonoma Technology, Inc.  
Petaluma, CA**

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# Overview

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- Introduction
- Review of Prior Analyses
- New Analyses
- Summary
- Modeling Recommendations
- Conclusions
- Discussion

# Introduction: General Questions

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- To what extent can we drive and evaluate diagnostic/prognostic meteorological models using the meteorological data collected? (*What can we do with the data?*)
- Do the simulated meteorology fields represent reality? (*Do the models produce anything useful?*)

# Introduction: Scope of Work

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- Adequacy and validity of measurement methods
- Sufficiency of data precision, accuracy, bias, consistency, and time-resolution
- Ability of models to represent important phenomena
- Model evaluation techniques
- Transport pathways

# Introduction: Important Processes

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- Stagnation
- Moisture/Fog/Stratus
- Vertical mixing (including plume rise)
- Precursor transport ( $\text{NO}_x$ )

# Introduction: Modeling Periods

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- CALMET (STI):
  - 12/24/2000 – 12/30/2000
  - 01/03/2001 – 01/09/2001
- MM5 (ARB):
  - 12/14/2000 – 01/08/2001 (No FDDA Case)
- Combined:
  - 12/25/2000 – 12/30/2000
  - 01/03/2001 – 01/08/2001

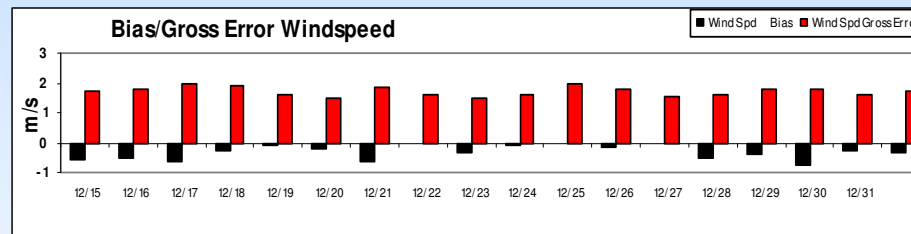
# Review of Previous Analyses

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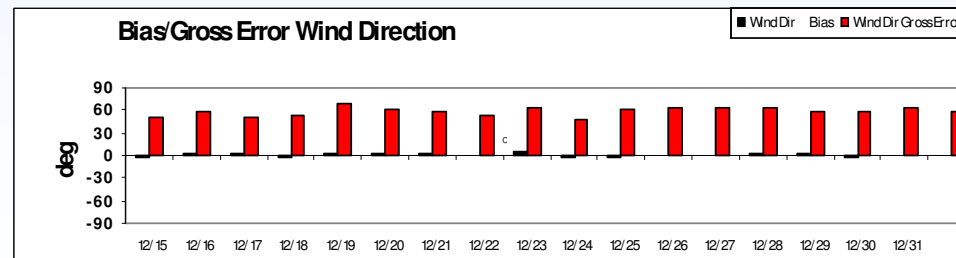
- Statistics (METSTAT)
- Time series plots (T, Q, WS, WD, PBL, VI)
- Spatial plots
- Vertical wind profiles
- Satellite image processing
- Soil temperature

# Winds

- CALMET generally replicates the observed winds with little or no bias except in cells near multiple observing sites
- MM5 wind speeds are generally underpredicted (bias  $\sim 0.4$  m/s overall)



- MM5 wind directions are generally unbiased





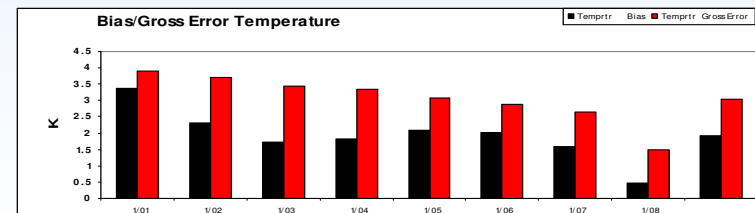
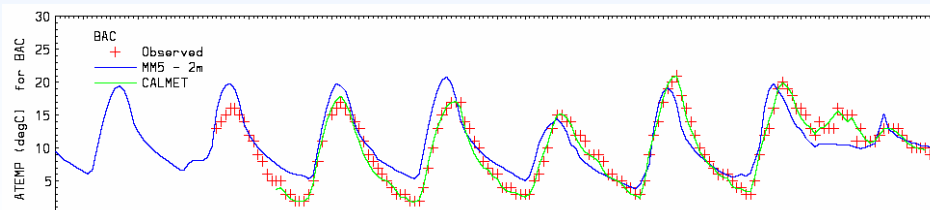
# Moisture

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- CALMET generally replicates the observed moisture with little or no bias but only provides relative humidity from the site nearest to each grid-cell
- During the first few simulation days, MM5 has a low bias. After 12/20, MM5 generally has a 0.5 g/kg high bias in water vapor mixing ratio
- MM5 trends are generally consistent with observations, but the diurnal cycle is damped (especially in central and southern SJV)) compared to the observations
- Nighttime mixing ratio errors are generally larger than daytime errors
- MM5 usually underpredicts nighttime maxima overpredicts daytime minima
- Errors are quite pronounced (bias approaching 2 g/kg) in the northern Sacramento Valley

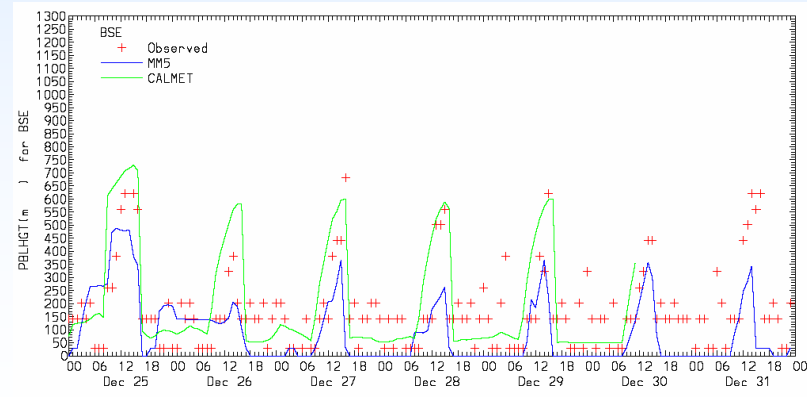
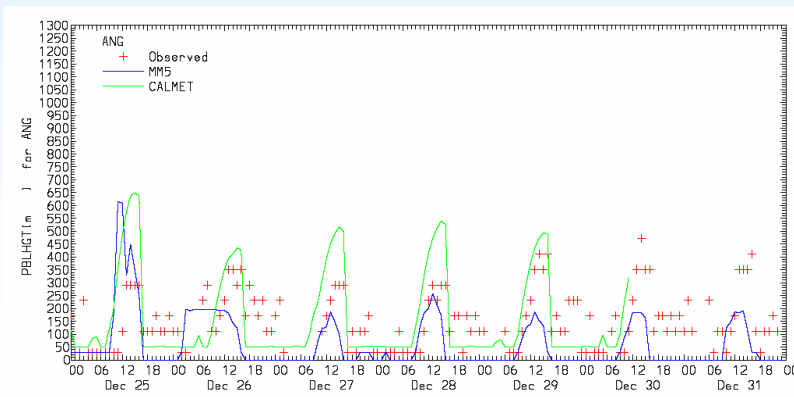
# Temperature

- CALMET generally replicates the observed temperatures with little or no bias
- MM5 temperatures are biased high through much of the simulation across the Central Valley, SFBA, and central coast
- MM5 often overpredicts both nighttime minimum and daytime maximum temperature
- Nighttime errors are generally larger than daytime errors.
- MM5 generally exhibits a damped diurnal cycle compared to observations



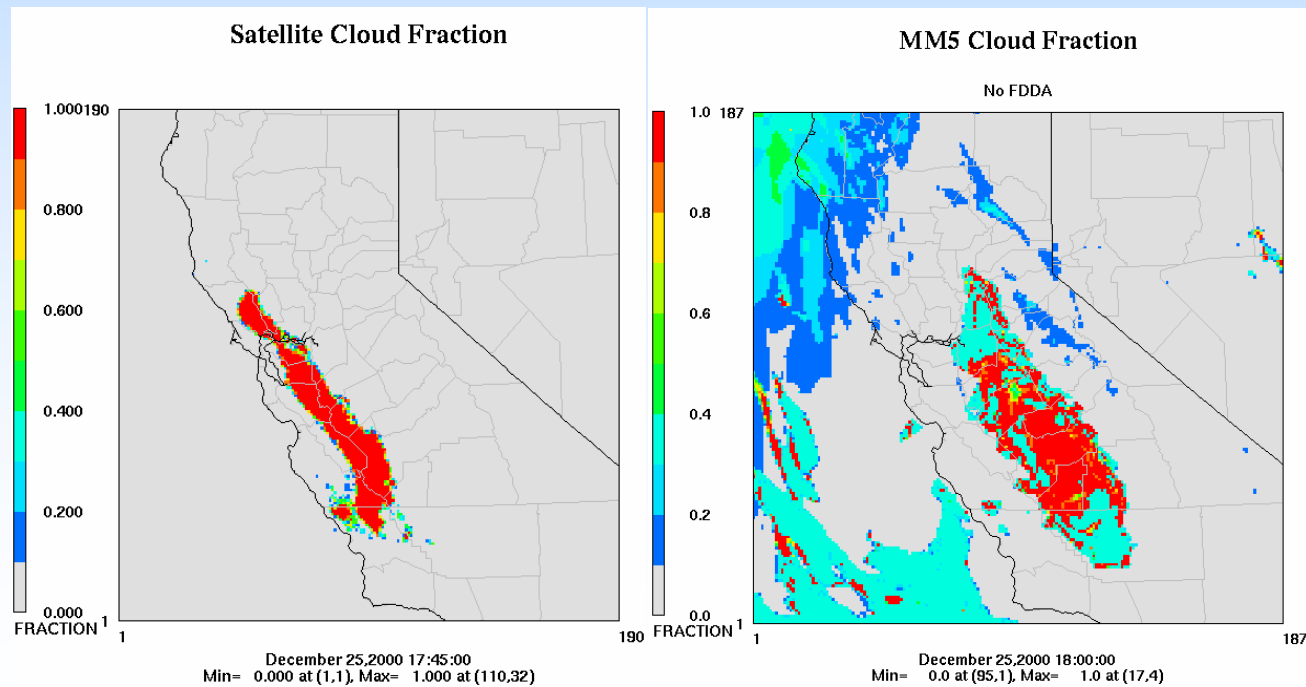
# PBL Height

- Both CALMET and MM5 underestimate nighttime PBL heights
- CALMET is biased high during the day but often gets the peak heights correct. However, mid-morning PBL heights rise too rapidly
- MM5 is biased low but often does better than CALMET with the mid-morning rate of increase



# Extent of Fog

- CALMET does not predict or output fog or clouds.
- MM5 tends to overestimate the extent of fog/stratus.



# New Analyses

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- Tracer Conservation
- Transport Statistics
- Extent of Fog/Stratus (additional)
- Tagged Tracer

# Tracer Conservation

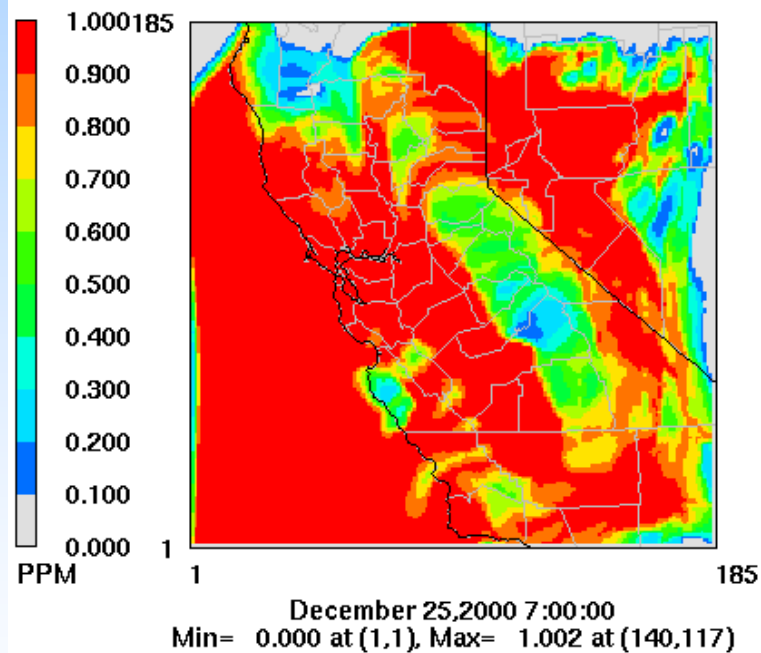
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- Purpose: Assess modeling systems' behavior
- CAMx simulations
- Meteorological processing
  - MM5CAMx
  - CMETCAMx
- Initial conditions: 1 ppm of inert tracer
- Emissions and boundary conditions: Zero
- Analysis
  - Surface concentrations
  - Mass balance
  - Peak tracer concentrations by region

# December 25: 7 Hours

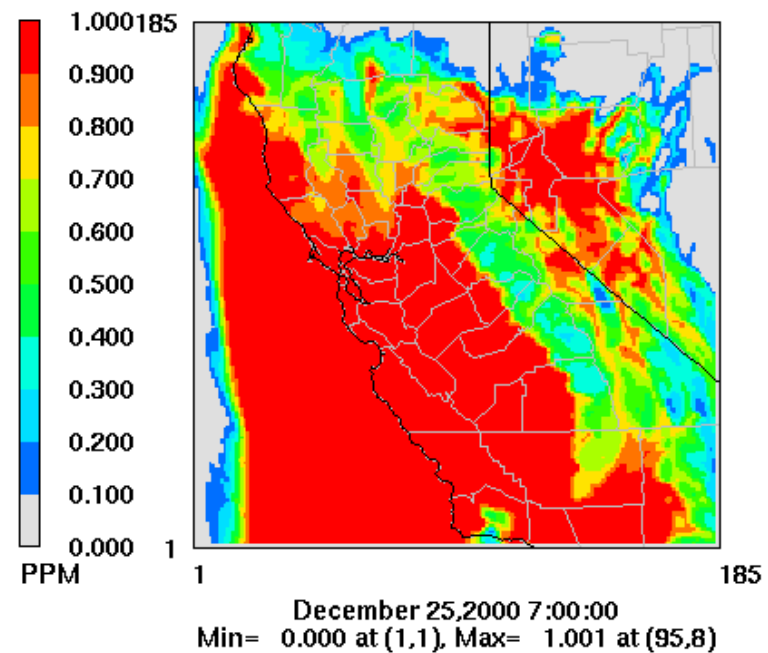
## CALMET Inert Tracer

December 2000  
CRPAQS CAMx Simulation



## MM5 Inert Tracer

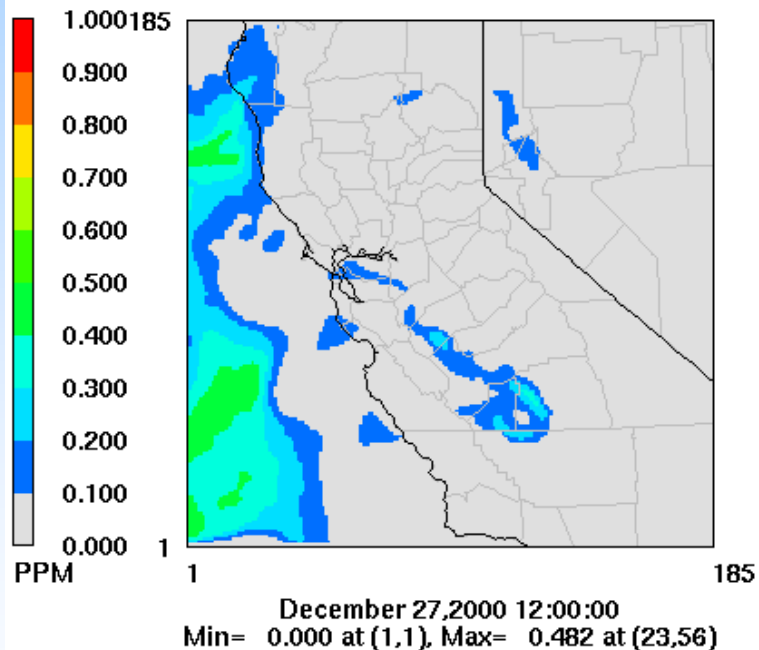
December 2000  
CRPAQS CAMx Simulation



# December 27: 60 Hours

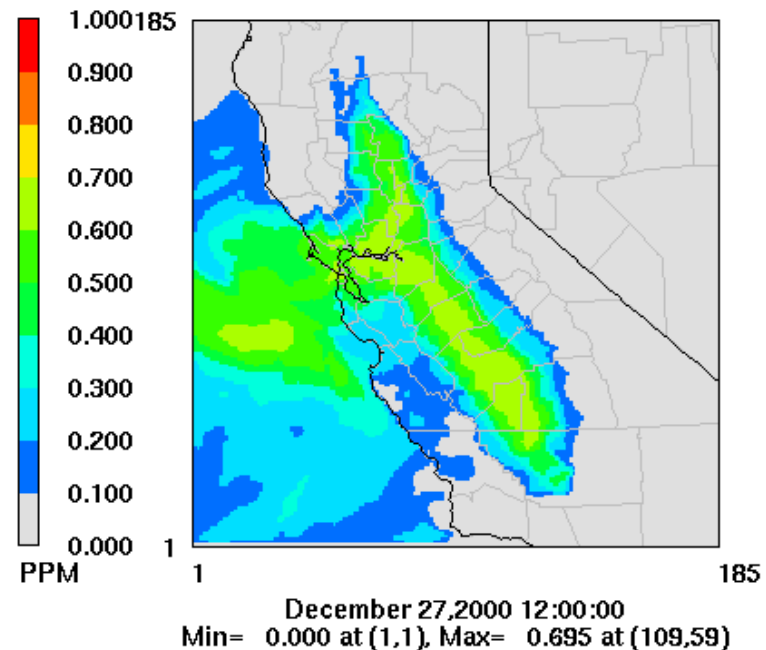
## CALMET Inert Tracer

December 2000  
CRPAQS CAMx Simulation



## MM5 Inert Tracer

December 2000  
CRPAQS CAMx Simulation

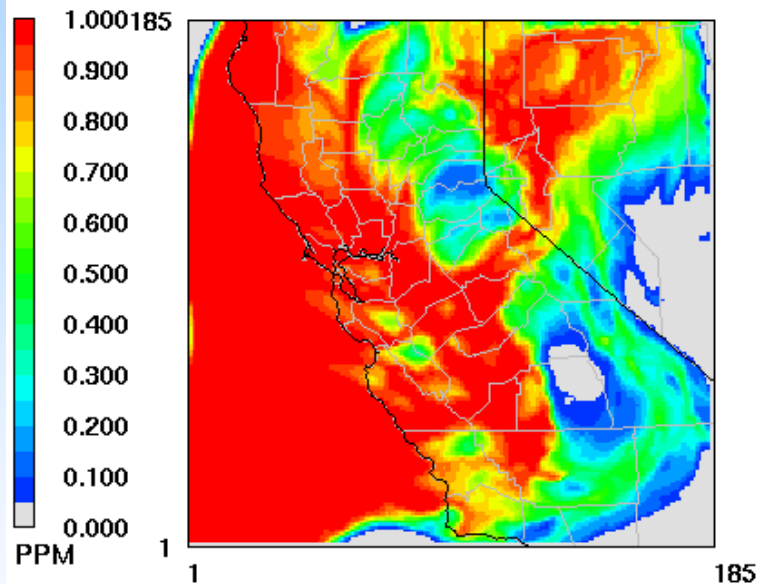




# January 3: 12 Hours

## CALMET Inert Tracer

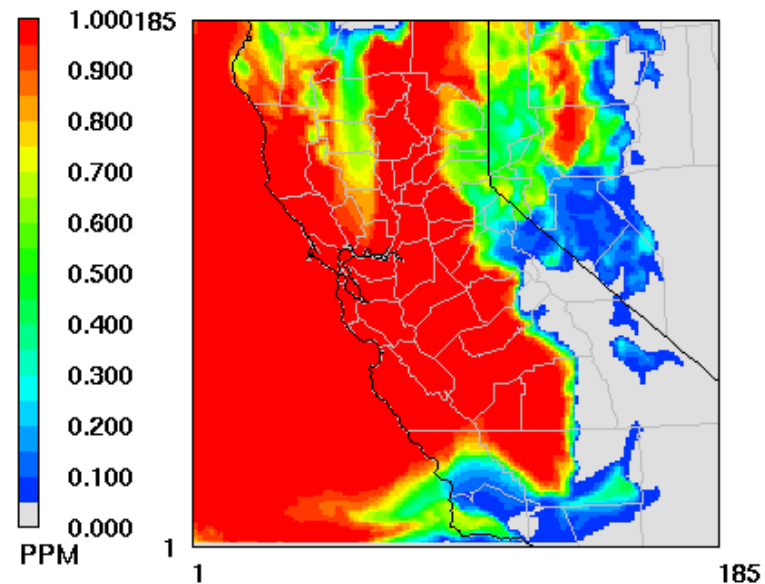
January 2001  
CRPAQS CAMx Simulation



January 3, 2001 12:00:00  
Min= 0.000 at (1,1), Max= 1.000 at (14,157)

## MM5 Inert Tracer

January 2001  
CRPAQS CAMx Simulation

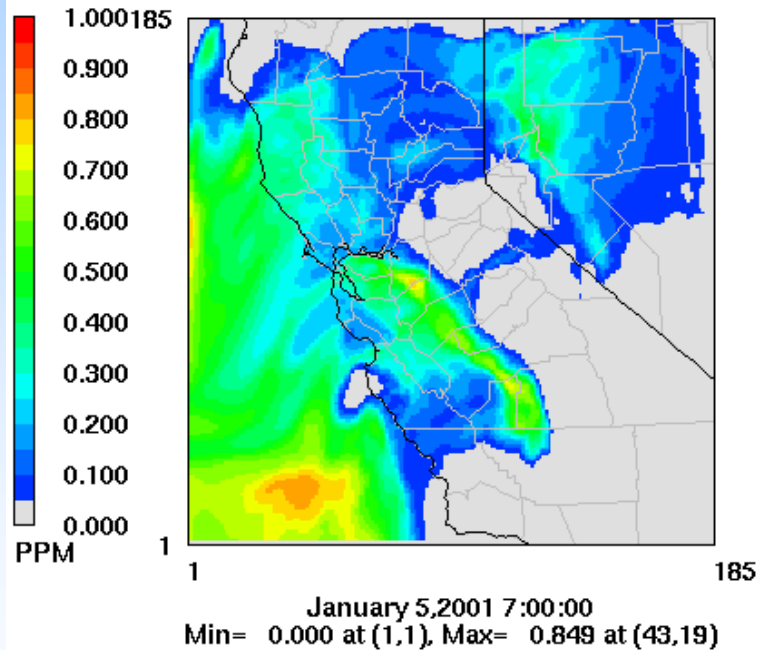


January 3, 2001 12:00:00  
Min= 0.000 at (1,1), Max= 1.011 at (75,52)

# January 5: 55 Hours

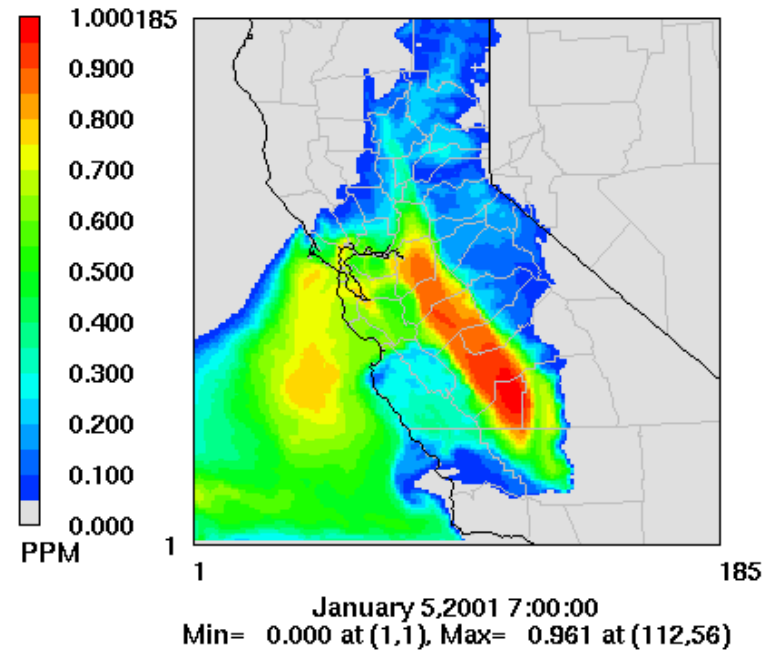
## CALMET Inert Tracer

January 2001  
CRPAQS CAMx Simulation



## MM5 Inert Tracer

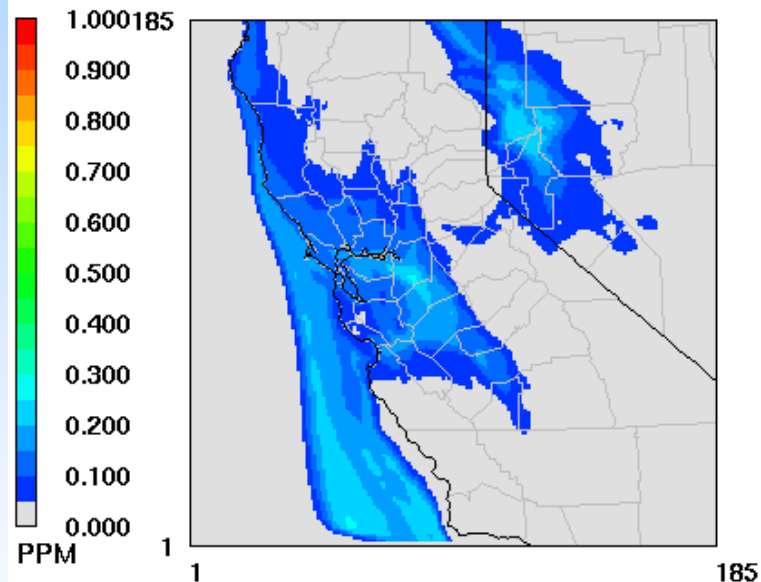
January 2001  
CRPAQS CAMx Simulation



# January 7: 96 Hours

## CALMET Inert Tracer

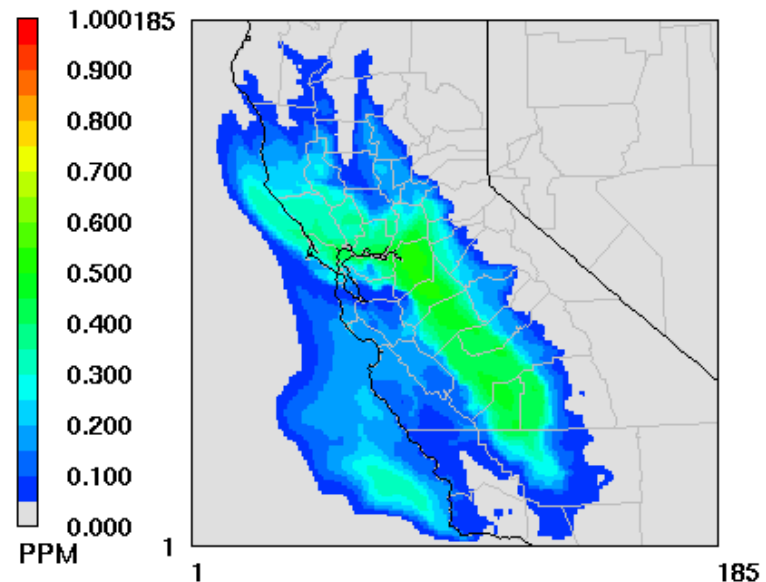
January 2001  
CRPAQS CAMx Simulation



January 7, 2001 0:00:00  
Min= 0.000 at (1,1), Max= 0.259 at (80,94)

## MM5 Inert Tracer

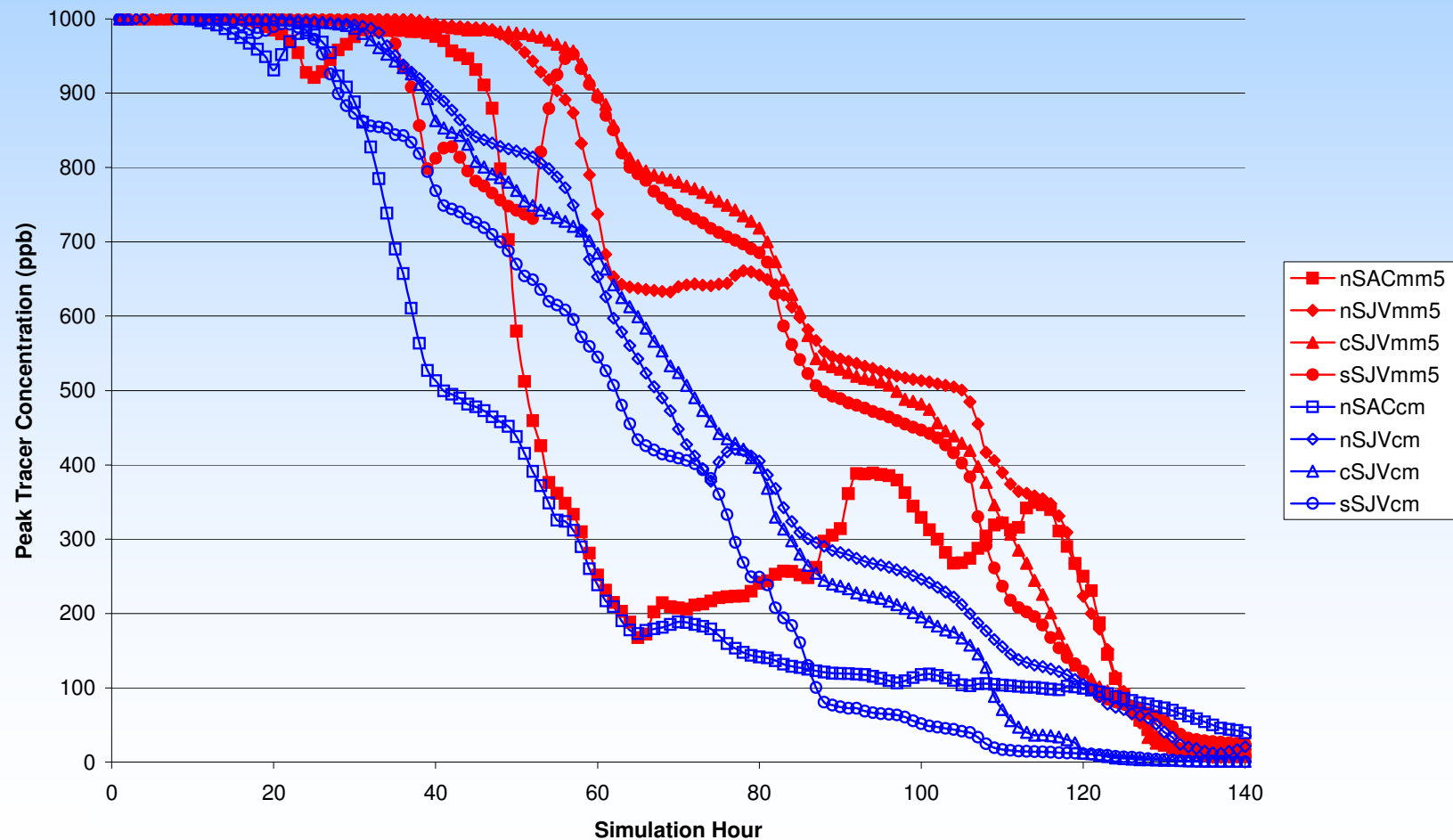
January 2001  
CRPAQS CAMx Simulation



January 7, 2001 0:00:00  
Min= 0.000 at (1,1), Max= 0.520 at (81,100)

# Peak Tracer Concentrations

MM5 vs CALMET Peak Tracer Concentrations  
January 2001 CAMx simulation



# Summary of Tracer Conservation

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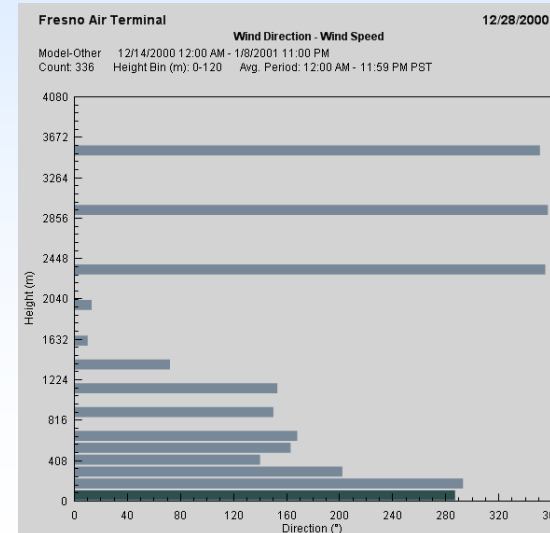
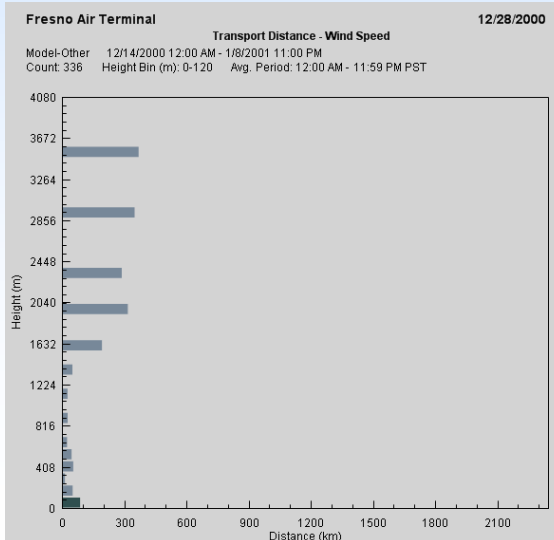
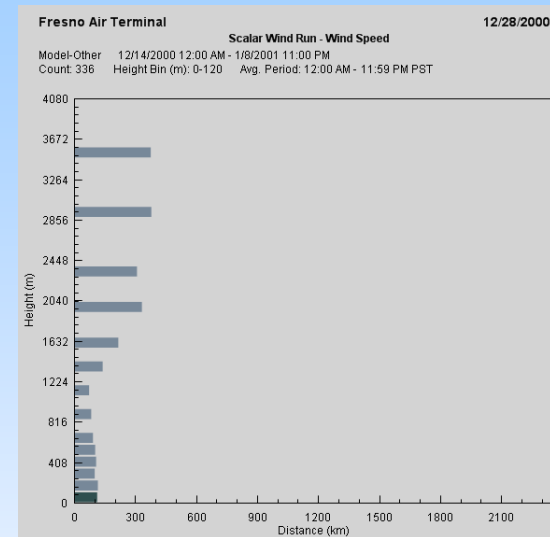
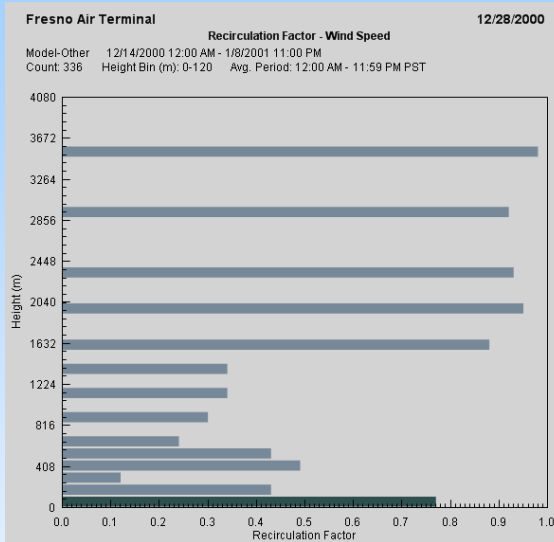
- CAMx loses mass faster with CALMET meteorology than with MM5
- CAMx-MM5 maintains a clearer separation of mass within the Central Valley
- CALMET is losing mass through vertical transport
- Evidence of observation-induced divergence is seen in CALMET, which may be useful for eliminating unrepresentative sites

# Transport Statistics (1 of 2)

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- Statistics:
  - Daily Transport Distance
  - Daily Wind Direction
  - Daily Scalar Wind Run
  - Recirculation Factor
- Calculated at RWP sites by vertical bins
- RWP, CALMET, and MM5 compared

# Transport Statistics (2 of 2)



# Extent of Fog and Stratus

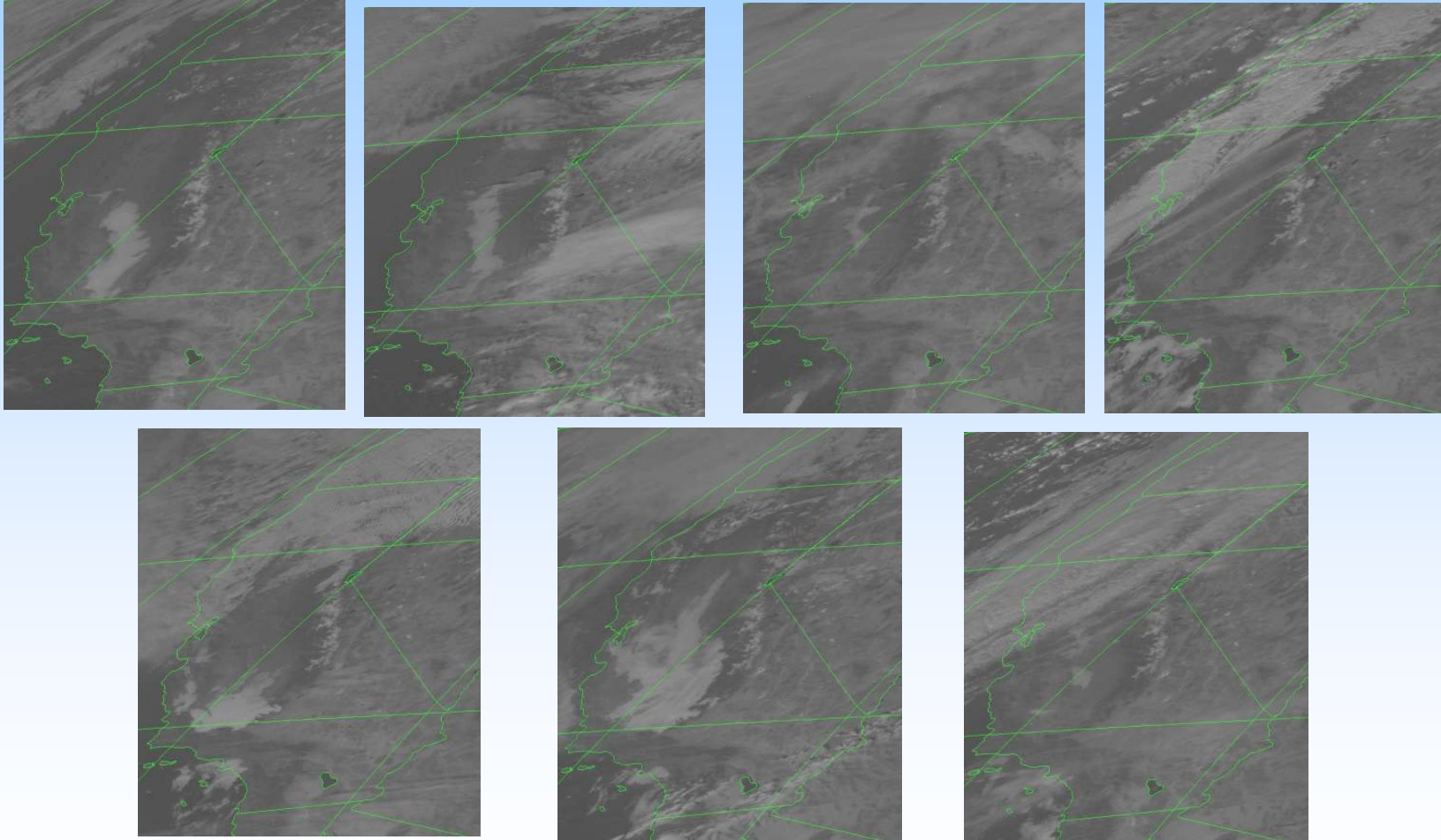
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- Additional days analyzed
- Labor intensive
- Objective vs. subjective analysis
- CALMET doesn't predict fog or stratus
- MM5 over-predicts the extent of fog and stratus:  
Consistent with over-prediction of surface moisture
- Future
  - Better geo-referencing of satellite images
  - Greater automation



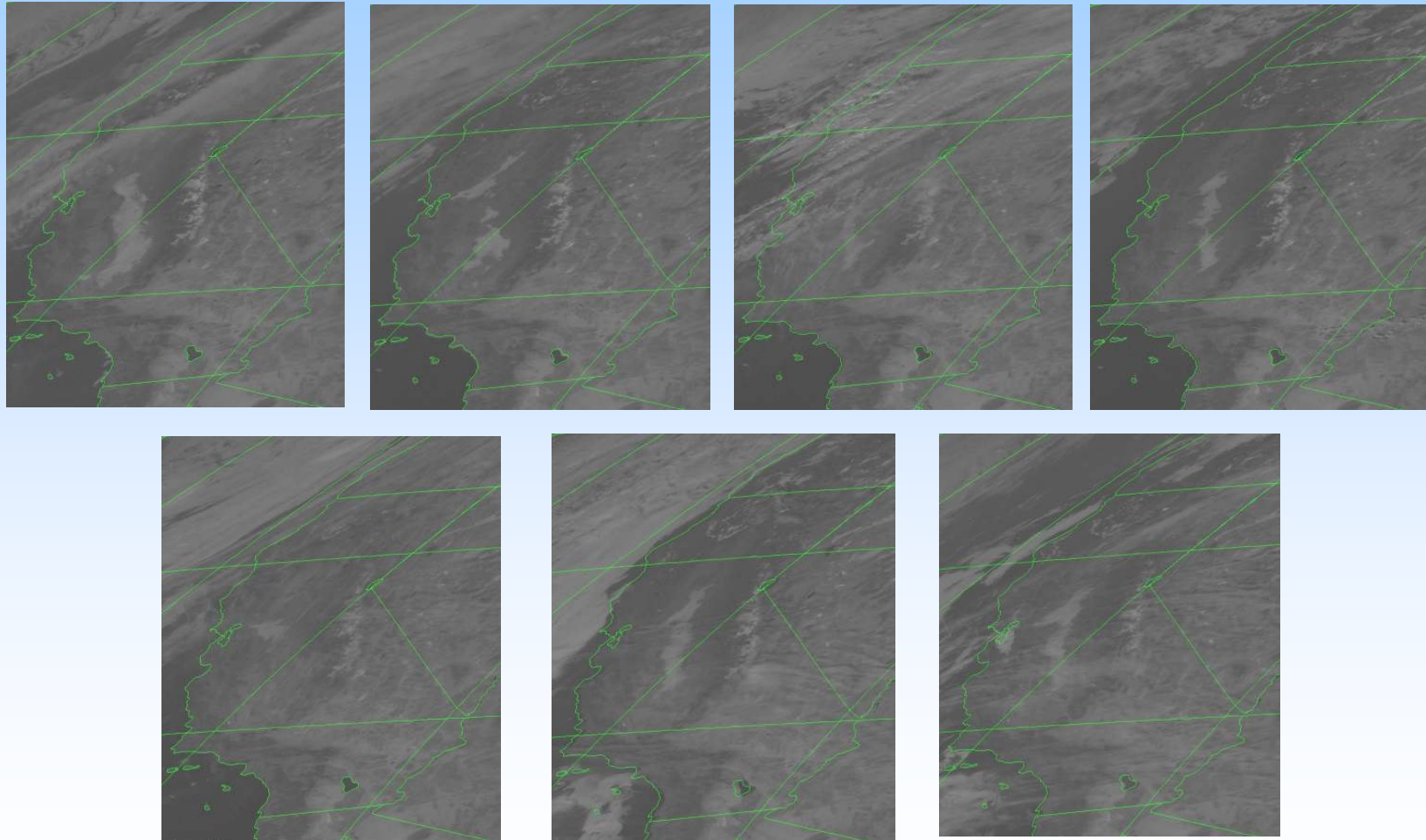
# Satellite 18-24 December 2000

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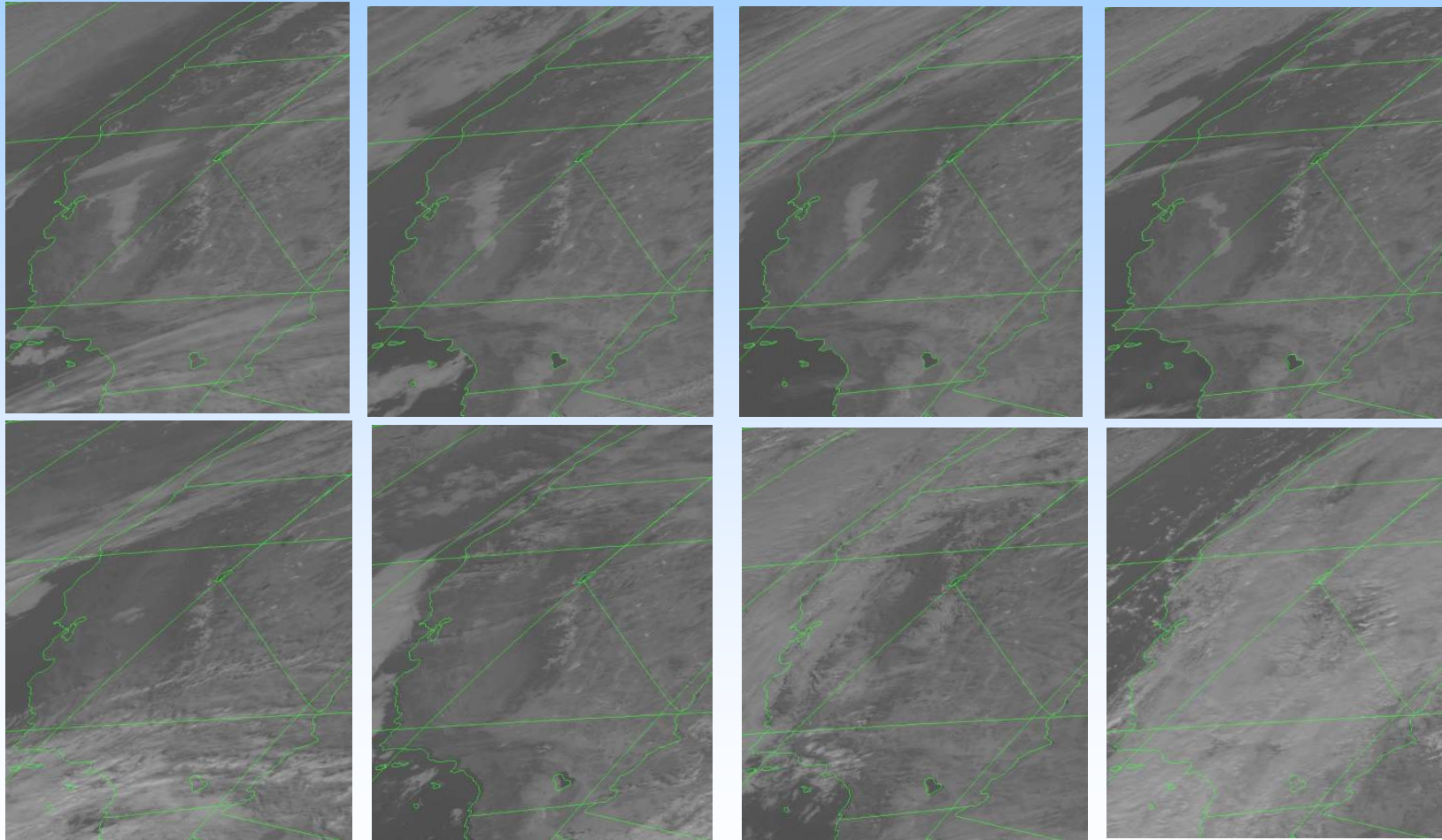
# Satellite 25-31 December 2000

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# Satellite 1-8 January 2001

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# Tagged Tracers

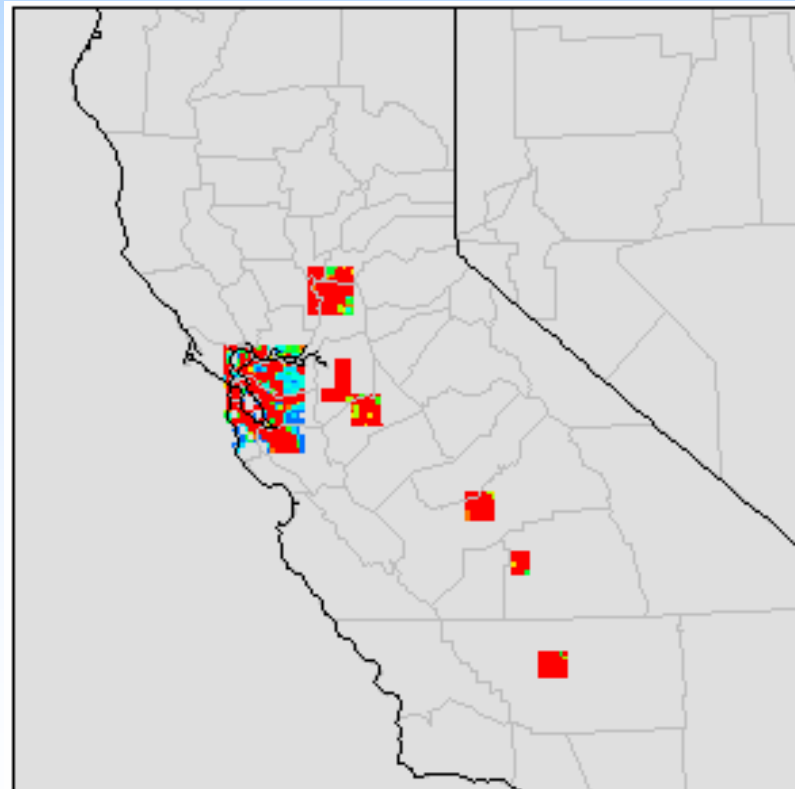
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- Purpose: Transport Analysis
- CAMx Simulations (same as tracer conservation)
- Initial and Boundaries Conditions: Zero
- Emissions
  - NO<sub>x</sub> emissions mapped as unique inert tracer species to 6 urban areas and 1 “all other” area
- Analysis
  - Surface concentrations
  - Contributions to concentrations at specific sites

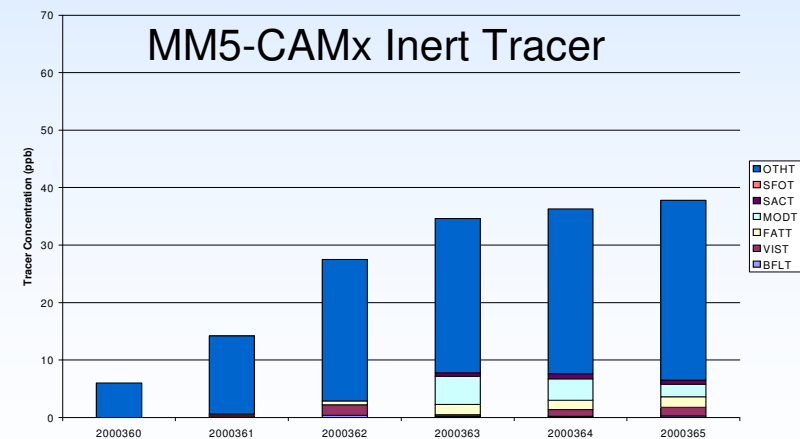
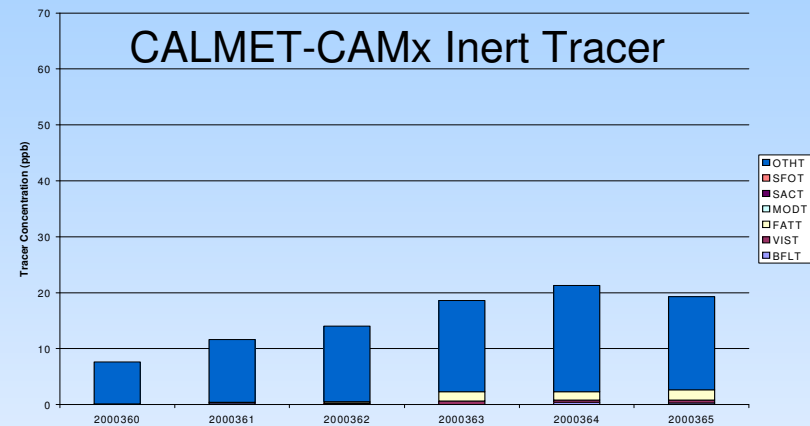
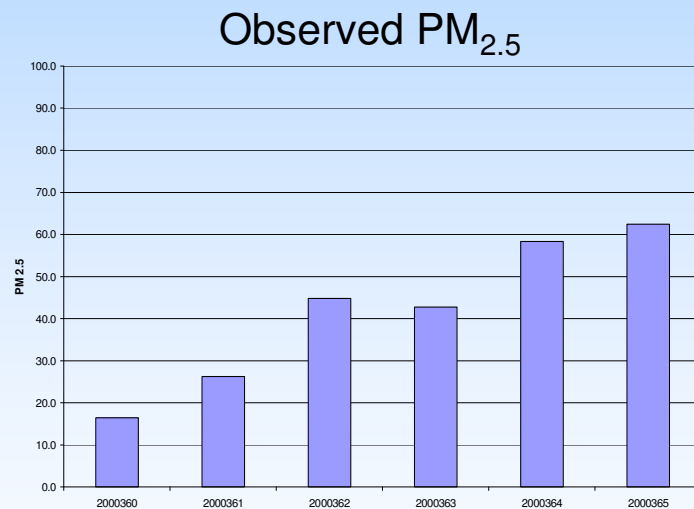
# Tracer Source Areas

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- Sacramento
- San Francisco Bay Area
- Stockton- Modesto
- Fresno
- Visalia
- Bakersfield
- Other

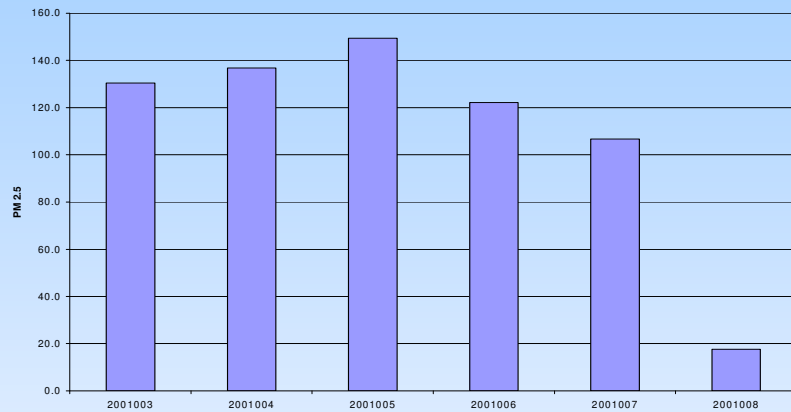


# Angiola: December 25-30 2000

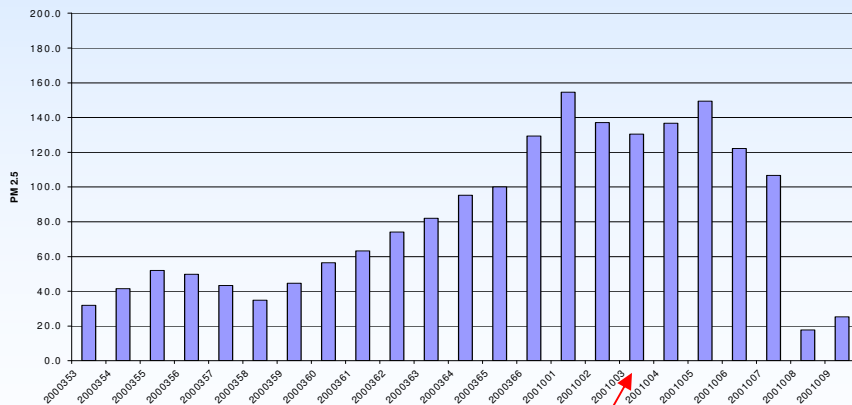
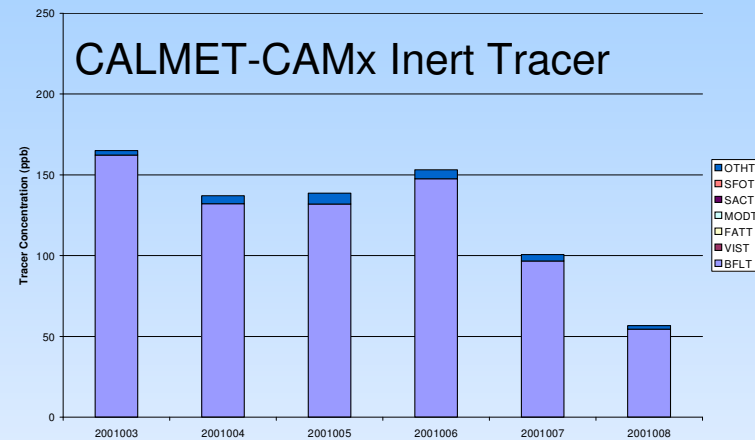


# Bakersfield: January 3-8 2001

Observed PM<sub>2.5</sub>

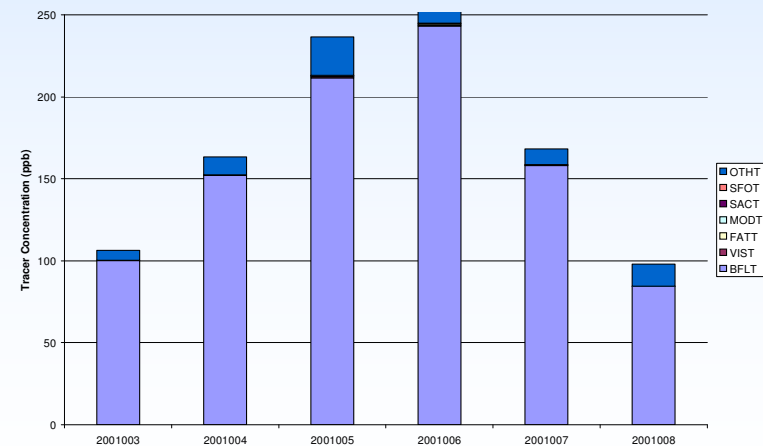


CALMET-CAMx Inert Tracer



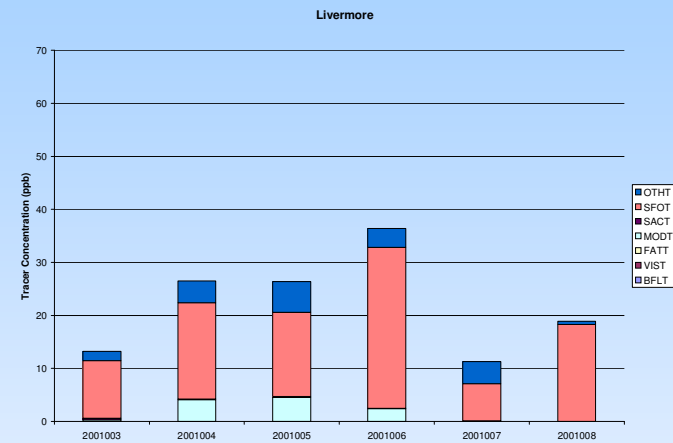
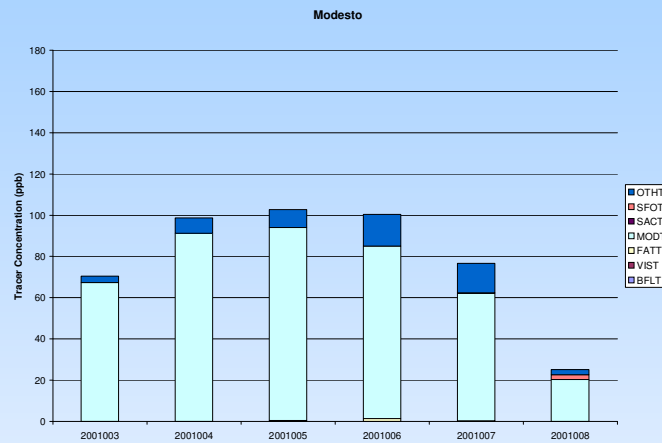
Jan 3

MM5-CAMx Inert Tracer

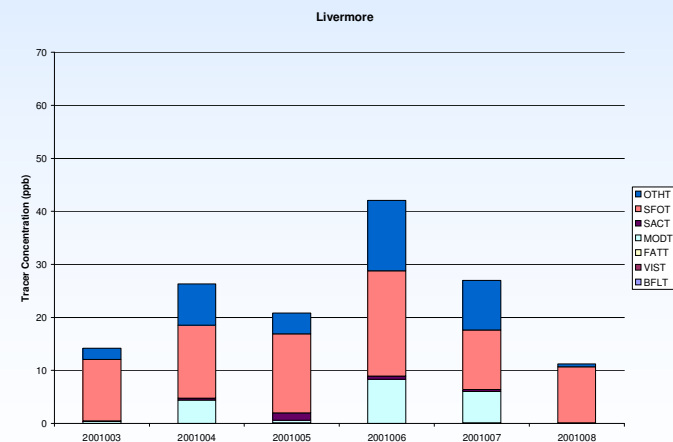
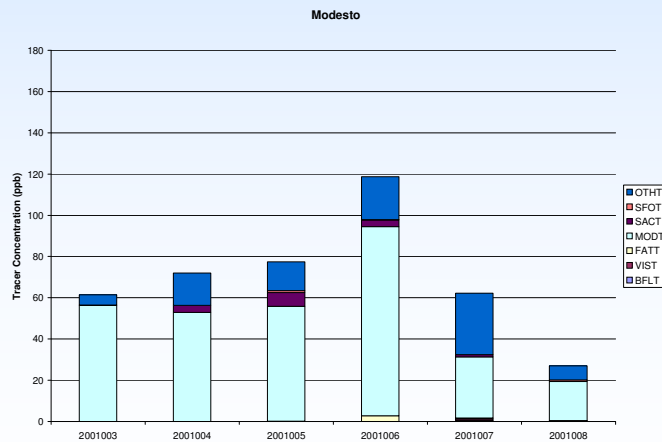


# Modesto and Livermore

CALMET

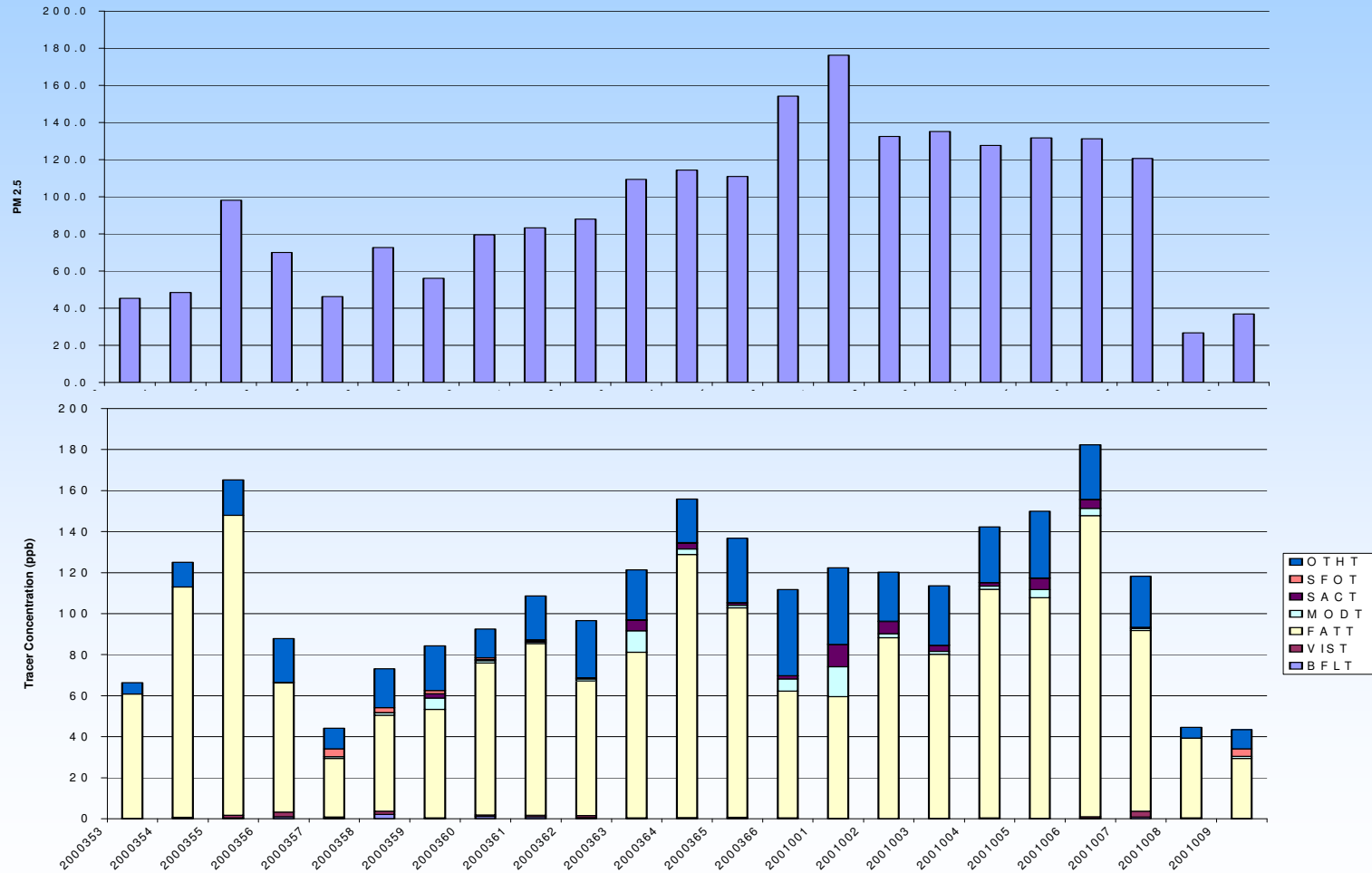


MM5





# Fresno: MM5-CAMx December 18 – January 9



# Summary of Tagged Tracers

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- Local tracer emissions dominate the total tracer concentration although 5 to 30% of the total tracer concentrations at the urban sites are from “rural” areas
- The relative contribution of rural tracers at urban sites is less in CALMET simulations than in the MM5 simulations
- Transport between the SJV, SV, and SFBA air basin occurs on some days but does not dominate most of the analysis period (Inter-basin transport)
- The relative contribution of non-local tracers (i.e., tracers not emitted from the area selected for analysis) is larger in MM5 than in CALMET (Intra-basin transport)

# Modeling Summary (1 of 2)

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- CALMET replicates meteorological values at measurement sites but may not correctly represent spatial gradients
- MM5 has biases in temperature, moisture, wind speed, extend of fog, and PBL height that may be related to the specification of moisture availability
- CALMET-CAMx appears to lose mass too fast from the Central Valley
- CALMET might be improved by more selective use of observational data but it is not clear if interpolation-induced divergence can be eliminated

# Modeling Summary (2 of 2)

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- MM5-CAMx maintains mass in the Central Valley longer than CALMET-CAMx but predicts greater non-local contributions to inert-tracer concentrations (even though it underestimates wind speeds)
- Significant modifications to CALMET would be required to provide the spatially varying (vertical and horizontal) moisture fields required by photochemical aerosol models

# Modeling Recommendations

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- Perform MM5 simulations with reduced moisture availability
- Consider use of a land surface model in MM5 simulations
- Consider use of FDDA in MM5 simulations
- Selectively reduce the number of sites used for objective analysis or data assimilation

# Conclusions

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- Adequacy and validity of measurement methods
- Sufficiency of data precision, accuracy, bias, consistency, and time-resolution
- Ability of models to represent important phenomena
- Model evaluation techniques
- Transport pathways

# Discussion

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## Analysis Products:

- <ftp://ftp.sonomatech.com/public/CRPAQS>

## Next Steps:

- Additional MM5 simulations?
- Plume-rise experiments
- Final Report and Presentation